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transformed by a process of the nature of catalysis, the product having as yet escaped discovery.

“That carbonate of soda injected into the liver after death does not effect a disappearance of hepatine, but even in moderate quantity holds the saccharine metamorphosis completely in check.

“That there is probably a close connexion between the disappearance of hepatine, the production of fat, and the state of the bile.”

*February 7, 1861.*

Major-General SABINE, R.A., Treasurer and Vice-President,  
in the Chair.

The Right Hon. the Earl of Ellesmere and Professor Harkness were admitted into the Society.

The BAKERIAN LECTURE was then delivered by Professor TYNDALL, F.R.S., “On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction.”

The Lecturer gave an account of the researches which form the subject of a paper with the above title, communicated by him to the Society; and in explaining the methods followed, he exhibited the apparatus which he had employed in his experiments. The following is an abstract:—

(Abstract.)

The apparatus made use of in this investigation consists of the following parts:—

1. A copper cube C, containing water kept constantly boiling, and one of whose faces, coated with lampblack, forms the source of radiant heat.

2. A brass tube 2·4 inches in diameter, which is divided into two portions,  $\alpha$  and  $\beta$ .

- $\alpha$ . The portion of the tube intended to receive the gases and vapours; it is stopped air-tight at its two ends by plates of transparent rock-salt, and is attached to a good air-pump, by which it can be exhausted at pleasure. The length is 4 feet.

$\beta$ . An air-tight chamber between the tube  $\alpha$  and the cube C. It is kept constantly exhausted; and the calorific rays, therefore, pass from the radiating plate through a vacuum into the tube  $\alpha$ , thus retaining the quality which belonged to them at the moment of emission.

To prevent the transmission of heat by conduction from the cube C to the tube  $\alpha$ , the chamber  $\beta$  is partly embraced by an annular space in which cold water continually circulates.

3. A thermo-electric pile furnished with two conical reflectors, and connected with an excellent galvanometer\*. One of the faces of the pile receives the rays which have passed through the tube  $\alpha$ .

4. A second copper cube C', also filled with boiling water, and whose rays fall upon the second face of the thermo-electric pile. The two cubes C and C' thus radiating upon the opposite faces of the pile, tend, of course, to neutralize each other.

Between the cube C' and the adjacent face of the pile, a screen S is introduced, being attached to an apparatus of Ruhmkorff, capable of extremely fine motion; by the partial advance or withdrawal of this screen the two sources of heat can be caused to neutralize each other perfectly.

The tube  $\alpha$  and the chamber  $\beta$  being both exhausted, the needle is brought exactly to zero by means of the screen S. The gas or vapour to be experimented with is now admitted into the tube  $\alpha$ ; and if it possess any sensible absorbing power, it will destroy the previously existing equilibrium. The consequent deflection of the galvanometer, properly reduced, is the measure of the absorption.

In this way the action of eight gases and thirteen vapours have been examined, and also the action of atmospheric air.

Oxygen, hydrogen, nitrogen, and atmospheric air, respectively, absorb about 0.3 per cent. of the calorific rays: this is the feeblest action which has been observed.

The most energetic action is that of olefiant gas, which at the tension of one atmosphere absorbs 81 per cent. of the calorific rays. Between those extremes stand carbonic oxide, carbonic acid, nitrous oxide, and sulphuretted hydrogen.

\* The author points out the means by which a galvanic coil of any length and of any degree of fineness, and possessing no trace of magnetism, may be obtained.

Below a certain tension, which varies for the different gases, the amount of heat absorbed is exactly proportional to the density of the gas.

Above this tension the rays on which the principal absorptive energy is exerted become gradually exhausted, so that every augmentation of density produces a diminished effect.

In the case of olefiant gas, for example, a unit-measure  $\frac{1}{50}$ th of a cubic inch in capacity being made use of; for a series of fifteen such measures the absorption was exactly proportional to the quantity of gas; subsequently the ratio of the successive absorptions approached gradually to a ratio of equality. The absorption produced by a single measure of olefiant gas of the above volume moved the index of the galvanometer through an angle of 2.2 degrees, the tension of the gas being only  $\frac{1}{11000}$ th of an atmosphere.

In the case of vapours, the most energetic is that of sulphuric ether; the least energetic is that of bisulphide of carbon. Comparing small volumes at equal tensions, the absorptive energy of sulphuric ether vapour is ten times that of olefiant gas, and ten thousand times that of oxygen, hydrogen, nitrogen, or atmospheric air.

On a fair November day the aqueous vapour in the atmosphere produced fifteen times the absorption of the true air of the atmosphere. It is on rays emanating from a source of comparatively low temperature that this great absorptive energy is exerted; hence the aqueous vapour of the atmosphere must act powerfully in intercepting terrestrial radiation; its changes in quantity would produce corresponding changes of climate. Subsequent researches must decide whether this *vera causa* is competent to account for the climatal changes which geologic researches reveal.

Oxygen obtained from the electrolysis of water exerted four times the absorptive energy of the same substance when caused to pass through iodide of potassium; the greater action being due to the presence of ozone.

The radiative power of gases was examined by causing them to pass over a heated sphere of metal, and ascend in a column in front of the thermo-electric pile; various precautions were taken, which are fully described in the memoir. It was found that the order of radiation was exactly that of absorption; that any atom or molecule which is capable of accepting motion from agitated ether, is capable,

in precisely the same degree, of imparting motion to still ether. Films of gas on surfaces of polished metal are shown to act like coats of varnish.

The author has appended a theoretic chapter to his memoir, in which he investigates the physical connexion of radiation, absorption, and conduction. In the foregoing experiments we have dealt with *free* atoms and molecules, and thus fixed upon them individually the responsibility of the effects observed. The effects are thus detached from considerations of cohesion and aggregation which suggest themselves in the case of liquids and solids.

He points out that the reciprocity of absorption and radiation is a necessary mechanical consequence of the theory of an ether.

But why is one molecule competent to stop or generate a calorific flux so much more powerfully than another? The experiments point as follows :—The elementary gases which have been examined all exhibit extremely feeble powers both of absorption and radiation in comparison with the compound ones. In the former case we have oscillating atoms, in the latter oscillating systems of atoms. Uniting the atomic theory with the conception of an ether, it follows that the *compound* molecule which furnishes *points d'appui* to the ether must be capable of accepting and generating motion in a far greater degree than the single atom, which we may figure to our minds as an oscillating sphere. Thus oxygen and hydrogen, which taken separately or mixed mechanically, produce a scarcely sensible effect, when united chemically to form oscillating systems, as in aqueous vapour, produce a powerful effect. Thus also nitrogen and hydrogen, which, when separate or mixed, produce but little action, when combined to form ammonia, produce a great action. So also nitrogen and oxygen, which, as air, are feeble absorbers and radiators, when united to oscillating systems, as in nitrous oxide, are very powerful in both capacities. Comparing small volumes at equal tensions, the action of nitrous oxide is 250 times that of air ; a fact, which perhaps furnishes a stronger presumption than any previously existing, that air is a *mixture*, and not a *compound*. Carbonic oxide is about 100 times as powerful as its constituent oxygen ; carbonic acid 150 times as powerful ; while olefiant gas, as already remarked, is 1000 times as powerful as its constituent hydrogen. In the case of the hydrocarbon vapours,

where the atomic groups attain a higher degree of complexity, the action is even greater than that of olefiant gas.

The author also refers to the experiments and observations of Niépce, Angström, Foucault; but more especially to the admirable researches of Kirchhoff and Bunsen, as regards the influence of the period of oscillation on the rate of absorption. He points out how the grouping of atoms to systems in a resisting medium must tend to make their periods of oscillation longer, and thus bring them into isochronism with the periods of the obscure radiations made use of in the experiments.

With regard to conduction, the author would illustrate his views by reference to two substances—rock-salt and alum. He was once surprised to observe the great length of time required by a heated mass of rock-salt to cool; but this was explained by the experiments of Mr. Balfour Stewart, who shows that rock-salt is an exceedingly feeble radiator. The meaning of this is, that the molecules of the salt glide through the ether with small loss of *vis viva*. But the ease of motion which they are thus proved to enjoy must facilitate their mutual collision. The motion of the molecules, instead of being expended on the ether between them, and then communicated in part to the ether external to the mass, is transferred freely from particle to particle; or, in other words, is freely conducted. This *à priori* conclusion is completely verified by the author's experiments, which prove rock-salt to be an excellent conductor. It is quite the reverse with alum. Mr. Balfour Stewart's experiments prove it to be an excellent radiator, and the author's experiments show it to be an extremely bad conductor. Thus it imparts with ease its motion to the ether, but finds difficulty in transferring it from particle to particle. Its molecules are, in fact, so constituted, that when one of them approaches its neighbour, a swell is produced in the intervening ether; this motion is immediately communicated to the ether outside, and is thus lost for the purposes of conduction. The lateral waste prevents the motion from penetrating the alum to any great extent, and hence it is pronounced a bad conductor. These considerations are dwelt upon more fully in the memoir of which this is an abstract; and they seem to reduce the phenomena of absorption, radiation, and conduction to the simplest mechanical principles.